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ABSTRACT The urban ecosystems we inhabit provide essential ecosystem services to humans, such as air pollution removal, as well as effective means to avoid costs related to urban development, such as stormwater treatment. A better understanding of the value of ecosystem services and their spatial distribution in urban areas is vital to widespread, holistic understanding of the relationship of environmental, economic, and social conditions. As such, it should be a component of education in grades 6-12, college, and continuing education. i-Tree Landscape is a free, online model developed by the USDA Forest Service in which users can select a geography (i.e. census block) to analyze ecosystem services provided by trees, explore demographics and forest composition, and prioritize tree planting and management activities. The program has the potential to act as a valuable tool for education, research, and advocacy related to urban and community forestry by providing data sets that are both easy to access and understand. However, as it is a recent addition to the i-Tree suite of tools, knowledge of its capabilities is relatively rare among urban and community forestry practitioners, and i-Tree is virtually unknown to the general public. Supported by a grant from the USDA Forest Service, this article describes an effort to assist in the dissemination of i-Tree Landscape, and the creation of educational materials outlining the functions of i-Tree Landscape and possible applications. Based on conversations with education and urban forestry experts, we have created educational materials for in-person workshops and have begun planning for modules that will be published on the i-Tree website. These materials are designed pertaining to the needs and experiences of the various intended user groups such as students in middle school, high school, and environmentally-focused college programs, community environmental organizations, and urban forestry professionals. It is our hope that effective educational materials and dissemination will help the people most likely to benefit from i-Tree Landscape's features to feel confident navigating the program and using it to serve their particular needs.

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INTRODUCTION

Ecosystem services, the benefits that nature provides to humans, are an area of increased interest and research in environmental studies and urban planning (Gómez-Baggethun & Barton, 2013; Sander et al., 2010). Nature provides services as straightforward as shade from trees, as well as those that are less straightforward and often more difficult to quantify, such as the removal of harmful air pollutants like tropospheric ozone (e.g., Bolund & Hunhammar, 1999; Livesley et al., 2016). In urban areas, green infrastructure, the employment of natural resources like vegetation to aid the reduction and treatment of stormwater, has been employed to avoid costs related stormwater treatment (US EPA, 2015).

The city of Chicago, Illinois has demonstrated a commitment to increasing green infrastructure (City of Chicago, 2014). Some measures taken by the city include tree planting, building drainage swales and rain gardens, and using permeable pavement (Roseen, 2011). Green infrastructure is incredibly valuable in a city like Chicago where the sanitary and stormwater sewage systems are combined. This combined sewage system is easily overwhelmed in cases of heavy rainfall, leading to sewer overflow events, which negatively impact both human and environmental wellbeing by releasing insufficiently treated sewage into waterways and drinking water sources (City of Chicago, 2014).

The city of Chicago reported in 2009 that a total of 70,182,236 gallons of stormwater was diverted from Chicago's combined sewer system from January to November, due to existing green infrastructure (Roseen, 2011). That number is likely to have grown due to the city's expansion of its green infrastructure (City of Chicago, 2014).

In order to properly convey the importance of ecosystem services to human wellbeing, researchers have developed several methods to assign them a value (Klimas et al., 2016; Nowak et al., 2008). While it is impossible to quantify the true worth of many of these services, the goal of researchers in assigning them a monetary value is to better incorporate ecosystem services in urban planning and decision-making (Boyer & Polasky, 2004; Spash & Aslaksen, 2015).

Though extensive knowledge of ecosystem services may not be widespread, ecological researchers have found values like dollars, avoided hospital visits, or avoided missed days of work are an effective translation for the general public and government decisionmakers (BenMAP, 2017). One way to calculate the value of ecosystem services provided by trees is described by Nowak (2014). The authors designed a method to calculate trees' effects on air quality based on total tree cover and leaf area indices, hourly fluxes of pollutants to and from leaves, and the effects of these fluxes on atmospheric concentrations of air pollutants (Nowak, 2014). In addition, their methods can be used to estimate trees' impacts on human health and monetary value associated with the change in atmospheric concentrations of air pollutants based on the U.S. EPA Environmental Benefits Mapping and Analysis Program (BenMAP) model (Nowak, 2014). In addition, an approximation of hydrologic benefits of trees can be calculated using weather data and leaf area indices (Hirabayashi & Endreny, 2016). Factoring in their effects on air quality, energy use, urban heat island effect, and property values, Chicago estimated the value of their 3,585,000 urban trees at $2.3 billion in 2015 (City of Chicago, 2014).

Building on this research, the USDA Forest Service, with cooperation from several organizations such as the Davey Tree Expert Company, designed the i-Tree suite of tools to "help strengthen forest management and advocacy efforts by quantifying forest structure and the environmental benefits that trees provide" (USDA Forest Service, "About i-Tree"). i-Tree offers useful, free means for advocacy, research, and education related to urban and rural trees all over the world. While there are many valuable tools within the i-Tree suite, this paper focuses on a recent addition, i-Tree Landscape.

The i-Tree Landscape tool possesses unique qualities when compared to other tools in the i-Tree Suite. While all i-Tree programs are free and available through the internet, many require extensive data input and background knowledge in forestry practices. Landscape is preloaded with data, from sources like the US Census Bureau, the National Land Cover Database, EPA models such as BENmap, and many more (US Census Bureau, 2015; US Department of the Interior, 2014; US EPA, 2017). It does not require any downloads and uses terms and formats that can be effectively translated to the general public, such as dollars saved by avoided stormwater runoff. Not only does the i-Tree Landscape tool allow users to see ecosystem services provided by trees in their area, they may also explore census data for the area, prioritize future tree plantings and other stewardship actions based on custom scenarios (USDA Forest Service, "i-Tree Landscape"). Overall, Landscape is the most user-friendly tool in the i-Tree suite to date, particularly for those without available data on tree cover in their area of interest.

While i-Tree Landscape appeals to a much broader audience than previous i-Tree tools, it cannot be considered truly accessible until public knowledge, both of the existence of the program and its capabilities, is more widespread. Some of the stated goals of Landscape are to justify more extensive natural resource management plans and assessment projects, like Urban Tree Cover analyses, and to present the importance of tree canopy for both traditional and new audiences (USDA Forest Service, "i-Tree Landscape"). In order for these goals to be achieved, this program must be brought to people who are most likely to use and/or benefit from the data it provides.

The objective of this study was to create user-friendly educational workshops and modules for the i-Tree Landscape tool. We define modules as self-contained units with designated learning outcomes (Donnelly & Fitzmaurice, 2005). This paper will focus on the use of educational best practices to create modules, while also discussing best practices for the dissemination of i-Tree Landscape.

METHODS

EDUCATIONAL MATERIALS

We determined best practices for creating educational materials related to the i-Tree Landscape tool through meetings with urban forestry and education practitioners and a literature review. Through private meetings with community forestry and urban forestry professionals, such as the Community Trees Program Specialist at the Morton Arboretum and the head of DePaul's Lab for Urban Forestry in the Anthropocene, and engaging with other practitioners in the field in workshops, we learned more about their professional needs. Our goal was to learn which features on the i-Tree Landscape tool best fit those needs, and therefore the features on which we should be most focused in future workshops and educational materials.

To discuss best practices for educational materials for multiple user groups, we met with an education specialist at DePaul's College of Education. She was able to provide valuable professional insight into the content and formatting of our materials, as well as additional resources that we explored in our literature review.

We completed a literature review regarding educational materials and comprehension. We focused on literature regarding how to address specialized vocabulary for the different levels of reading comprehension of middle school, high school, environmentally-focused college students and urban forestry professionals, as well as how to determine which words are considered specialized or difficult for most audiences.

We based the scope of our educational materials on learning outcomes we established for each of i-Tree Landscape's intended user groups. Learning outcomes for middle school and high school students were developed in conjunction with the Next Generation Science Standards for these grade bands in the discipline of Life Sciences and the disciplinary core idea Ecosystems: Interactions, Energy, and Dynamics ("HS-LS2, 2013"; "MS-LS2", 2013). We based the learning outcomes for college students, community environmental groups, and urban and community forestry practitioners on the learning outcomes for DePaul's Environmental Studies major (DePaul University, 2018), the stated goals of the National Urban and Community Forestry Challenge Cost-Share Grant Program which funded this study (USDA Forest Service, 2014), and the stated goals of i-Tree Landscape (USDA Forest Service, "About i-Tree"; USDA Forest Service, "i-Tree Landscape"). We then articulated learning outcomes to each individual module.

In our workshops, we offered interactive walk-throughs of the i-Tree Landscape tool with the aid of a slide presentation or by working directly in the program on the projector screen. In addition, we are in the process of creating online training materials to be posted on the i-Tree website for wider audiences.

DISSEMINATION

We disseminated i-Tree Landscape educational materials during the meetings and workshops with professionals, by asking these professionals for other groups or individuals who would be interested in i-Tree Landscape, and through the personal and professional networks of the authors and members of the research team. These methods resulted in engagement of the following groups and organizations in the dissemination process: The Morton Arboretum, the Illinois Arborist Association, the Gary, Indiana Office of Environmental Affairs (open to the public), and the DePaul University Department of Environmental Science and Studies.

RESULTS

DEVELOPMENT OF LEARNING OUTCOMES

We first developed overall learning outcomes for each user group: middle school students, high school students, college students, urban and community forestry professionals, and community environmental groups (See Appendix A). College students in environmentally-focused programs, community and urban forestry professionals, and community environmental organizations were grouped together, as we found their levels of urban forestry knowledge and the demands of their field regarding urban trees to be comparable.

DEVELOPMENT OF EDUCATIONAL MATERIALS

Based on our meetings with an expert at DePaul University's College of Education (M. Donovan, pers. comm., 11 January 2018), we determined some of the educational best practices on which we should be most focused for our i-Tree Landscape materials. Those best practices include support for specialized vocabulary, understanding the needs and experiences of different user groups, modularization of content, and explaining both the operation and potential uses of i-Tree Landscape features.

The i-Tree Landscape tool uses both Tier 2 and Tier 3 vocabulary. Tier 1 vocabulary is so commonly used it is usually learned without formal instruction before primary school entry, therefore, it is not a subject of this paper (Beck et al., 2013). Tier 2 vocabulary, also known as core vocabulary, usually has several meanings, therefore people are likely to have more exposure to these words and a greater understanding of their potential definitions. Tier 3 vocabulary is more unique, usually only has one meaning, and is encountered less often. Due to this lack of exposure, Tier 3 vocabulary often requires greater guidance to ensure its comprehension by the audience (Hiebert, 2012).

Hiebert (2012) describes the concept of "spiraling curriculum," in which the understanding of a technical term, Tier 3 vocabulary, requires the understanding of another, simpler technical term, also Tier 3 vocabulary. Hiebert states, "It is important that students learn the basic concepts when they are introduced because the knowledge underlies more advanced concepts and that foundation will be needed again and again." (2012, p. 6). An example of how we applied this concept to our educational materials was in our definition of ecosystem services (See Figure 1). An understanding of ecosystem services is vital to grasp several other components of the i-Tree Landscape model that use more technical terms, like hydrology (See Figure 2).

Figure 1. Introduction slide on ecosystem services from high school-level workshop.

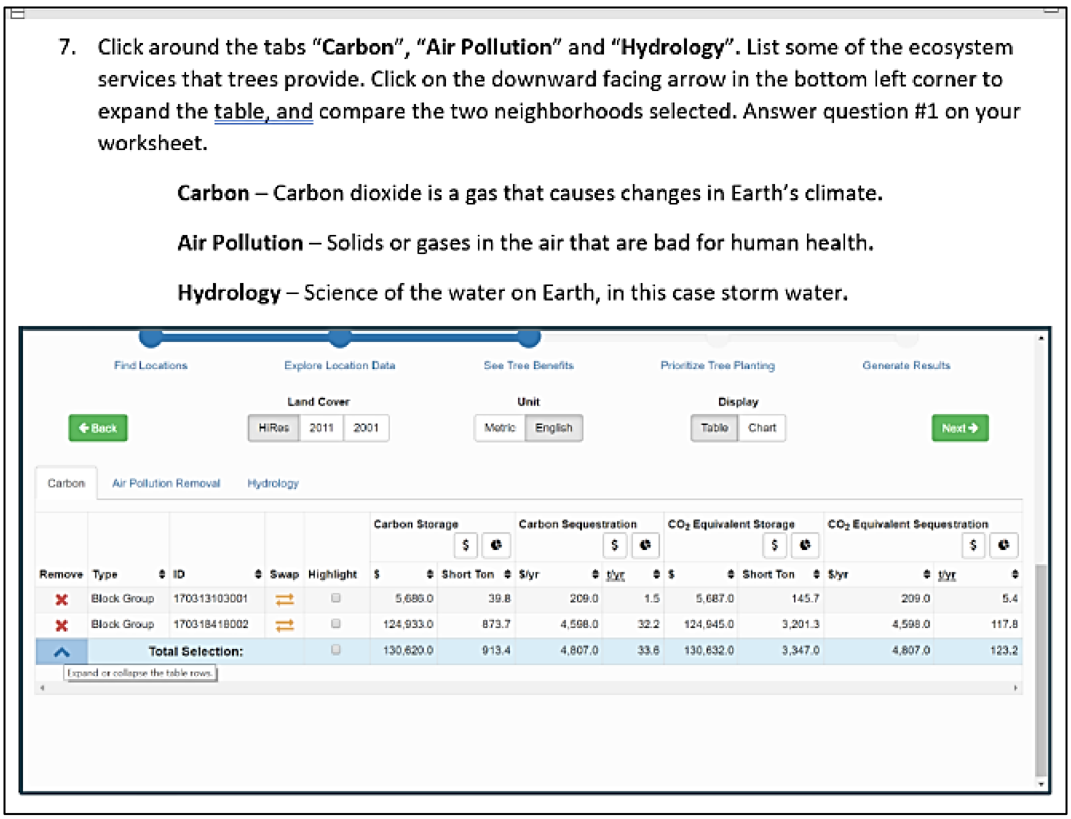

Figure 2. Module regarding tree benefits (ecosystem services) from high school-level workshop.

As the level of technical urban forestry and ecosystem services knowledge varied among workshop groups, the depth to which we went defining terms also varied. We found that defining terms like ecosystem services and hydrology was much more important for student group comprehension, and largely unnecessary with environmental professionals (i.e. government employees or urban and community forestry practitioners). In the case of environmental professionals, understanding of these technical terms was either assumed or quickly reviewed out loud, rather than included in the text of the presentation.

In addition to varying levels of urban forestry knowledge, we found that the different user groups were more interested in particular features of the i-Tree Landscape program based on their needs (B. Corrigan, pers. comm., 18 September 2017). For example, with urban and community forestry practitioner workshop groups, we emphasized the features that allow users to prioritize tree planting in specific areas based on self-defined criteria, and how to use the map layers provided by i-Tree Landscape, such as land cover, to scout possible planting locations on public and private property (J. Vogt, pers. comm., October 2017; See Figure 3). In addition, this group was interested in how exploring the valuation of ecosystem services provided by trees can be used as a tool for advocacy. For student groups, the main focus of the workshops was ecosystem services. For high school students and college students in environmentally-focused programs, we went into greater detail about how ecosystem services are valued, and what advantages this valuation provides to advocacy efforts (See Figure 4).

The breakdown of educational content into modules, units with their own learning outcomes (Donnelly & Fitzmaurice, 2005), allowed us to illustrate the functions of i-Tree Landscape while addressing the particular needs and urban forestry knowledge of different user groups. We created modules for different tools or sections within i-Tree Landscape (See Figure 5). Our desired learning outcomes for each module were based on the audience's understanding of the functioning of the tool, as well as its possible real-world applications (See Appendix B). For example, we had a module based on the "Explore Location Data" page of i-Tree Landscape that describes census data and forest composition in the selected area. In the module we also discussed

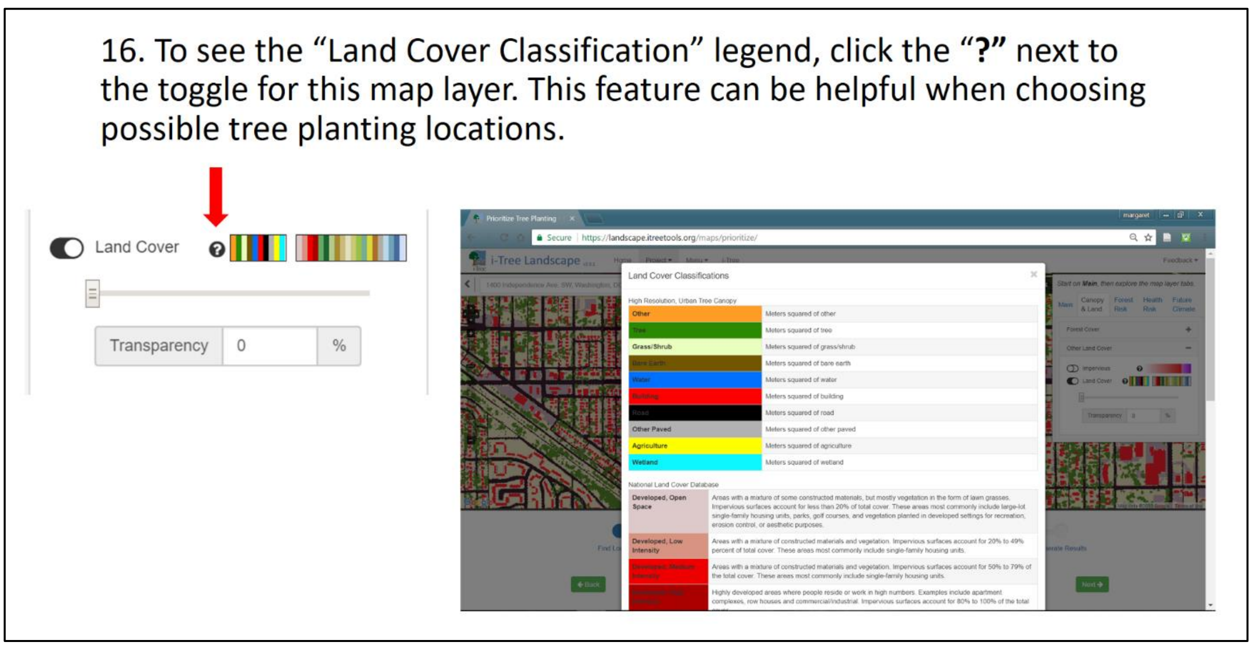

Figure 3. Module regarding prioritizing and planning tree planting sites from Gary, Indiana Department of Environmental Affairs workshop.

Click **See Tree Benefits**, and then the tabs for **Carbon, Air Pollution Removal, and Hydrology** to explore the ecosystem services trees are providing for the town of Tinley Park.

** How would you present this information to employees or elected officials in the municipality? What information do you believe would be the most helpful in presenting your case for planting more trees in the area?

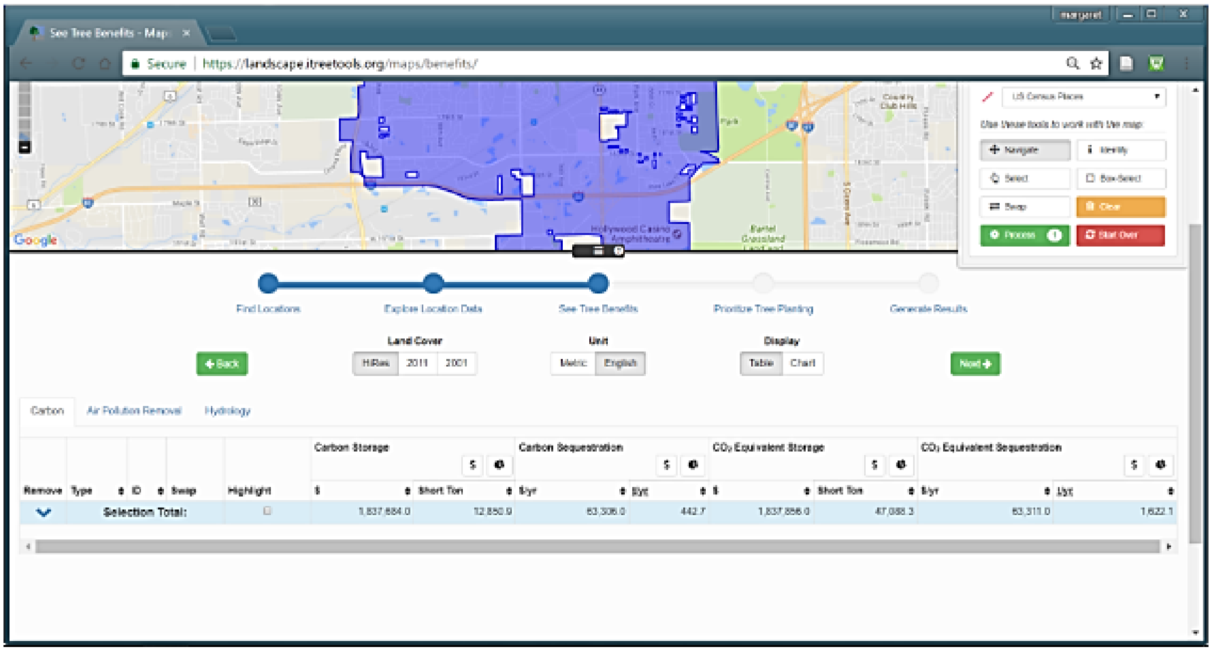

Figure 4. Module regarding tree benefits (ecosystem services) and potential presentations of data for advocacy purposes from college-level workshop.

how the data found on this page can be used to explore the relationship of social demographics and tree cover. We emphasized particular modules based on the needs of each workshop group. This modularization also aided us in addressing how to explain potential uses of individual program features, as well as the program as a whole either through text in the presentation or aloud (See Figure 6).

DISSEMINATION

Thus far, we have worked within the Greater Chicago Metropolitan Area to disseminate i-Tree Landscape. We have taught a series of workshops to audiences of vastly different levels of urban and community forestry experience, such as middle school, high school and college students in environmentally-focused programs, a workshop group of Illinois Arborist Association members, and government employees in Gary, Indiana.

Many of our initial contacts for dissemination of the i-Tree Landscape tool and related educational materials were the result our team's professional network built through the DePaul University community. The DePaul University Department of Environmental Science and Studies has a good working relationship with Chicago's Morton Arboretum. It was through this contact that we discovered the opportunity to present a workshop with members of the Illinois Arborist Association. Several members of the Environmental Science and Studies Department faculty and student body are well connected in the Chicago and Northwest Indiana urban forestry communities and were able to help us find interested parties in those communities, as well.

Figure 5. Beginning of module regarding geographic data from Illinois Arborist Association workshop.

Figure 6. Summary of i-Tree Landscape's potential uses from Illinois Arborist Association workshop.

The department has a relationship with several summer and after school programs like the Green Teens at the Gary Comer Youth Center. For groups like the Green Teens, we have adapted the workshop content into an interactive activity to do with middle and high school-aged students for science-themed field trips. We also reached out to professors within the Department of Environmental Science and Studies whose classes' curriculum we believed to fit with this project. As a result, we presented a workshop to a group of students in the ENV 341: Urban Forests as Social Ecological Systems class at DePaul.

In addition to more workshops, our next stage of education and dissemination will be focused on creating user-friendly educational modules and webinars to be published on a USDA Forest Service website to make i-Tree Landscape easily accessible to any audience with internet access. In addition, we hope to expand our local dissemination using the same methods mentioned in this paper.

DISCUSSION

Initial feedback from education experts and urban forestry professionals illustrated three distinct user groups, each with specific preferences and needs that can be served by i-Tree Landscape. Essential to the development of educational materials was the establishment of learning outcomes for these various user groups. Due to the different user groups, different modalities of dissemination must be considered in the future to ensure the success of i-Tree Landscape.

Most of our opportunities for dissemination and education were the result of relationships built through the DePaul University community. In this case, the value of making connections through university networks for the sake of dissemination cannot be overstated. Through our workshops, we have encountered many individuals and organizations interested in hosting an i-Tree Landscape workshop of their own. While we already make our contact information available to attendees, we will use an optional sign in sheet at future workshops to follow up with parties who seem interested in more information or hosting a workshop.

We can further expand our reach by contacting more urban forestry and arboriculture professional networks, such as the International Society for Arboriculture. In addition, the USDA Forest Service and private urban and community forestry groups may be interested in hosting an i-Tree Landscape webinar. Some of the urban forestry professionals with whom we engaged when strategizing for dissemination are well connected across several user groups. Leveraging their networks (i.e. via listservs) would facilitate more rapid dissemination to potential users.

The best practices for dissemination previously mentioned mostly apply to in-person workshops, however, we will also be publishing educational materials on the i-Tree website in the future. Dissemination of these materials will be largely dependent on publicity generated by the USDA Forest Service so potential users know such a tool as i-Tree Landscape exists, how it is used, and how its capabilities may meet their needs. In addition, dissemination will be dependent on how effectively the online modules meet and emphasize the needs of multiple user groups.

For educational materials published online, there will have to be several different considerations that do not typically apply to in-person workshops. We would like there to be separate pages or activities for different user groups, such as students of various grade levels (6-8, 9-12, college) or urban forestry professionals. We have found the needs and existing urban forestry knowledge of these groups to be very different. Therefore, it would be advantageous to have separate resources and activities that specifically pertain to the needs of an intended user group.

While it would be valuable to have modules that illustrate all features of the i-Tree Landscape tool, the density of that information may be overwhelming and decrease the likelihood of its implementation by some user groups. To increase the likelihood of user groups' actual implementation of the tool as a method of education, urban and community forest management, and/or advocacy, we must promote modules pertaining to the features most valuable to each user group. Publishing materials catered towards particular user groups would allow us to focus on the gaps that may exist in a user group's knowledge that necessitate further instruction, without being redundant in materials intended for more advanced groups.

We would also like to have materials dedicated to training people who may be training groups of their own on how to use the i-Tree Landscape program, such as teachers. The online modules developed for middle and high school students and their teachers will have a basis in the Next Generation Science Standards, so activities can be easily integrated into their existing science curriculum (“Next Generation”, 2013).

In addition to PDF or slideshow instructions, we believe it would be valuable to publish video walkthroughs with an audio component for audiences that may need more step-by-step instruction and description of i-Tree Landscape features. Optional quizzes and activities that interrupt the video walkthroughs would also encourage reflection and retention of instructional content. Activities would strengthen critical thinking regarding potential uses for the i-Tree Landscape tool (Bean, 2011). Thus far, such quizzes or activities have been difficult to integrate into in-person workshops, as time is always a major limitation.

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APPENDIX

Appendix A: User Group Learning Outcomes

User Group	Learning Outcomes
Grades 6-8	List and explain the ecosystem services trees provide (pollution removal, carbon sequestration, avoided storm water runoff, etc.). Map and compare how tree cover varies across geographies based on scientific, economic, and social constraints. From the Next Generation Science Standards (MS-LS2, 2013): MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.][1]
Grades 9-12	List and explain the ecosystem services that trees provide and how they are quantified and valued. Map and compare how tree cover varies across geographies based on scientific, economic, and social constraints. From the Next Generation Science Standards (HS-LS2, 2013): HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.][2]
College students, urban forestry practitioners, community organizations	Proficient in tool use. Demonstrate methodology of i-Tree Landscape to quantify and value ecosystem services provided by trees (pollution removal, carbon sequestration, avoided storm water runoff, etc.). Understand how to create visual representations of tree cover and associated benefits. “Identify the scientific, political, economic, social and ethical components of both the causes and solutions to environmental issues” (Environmental Studies (BA), 2018) in urban areas and their relation to urban tree cover • Map and identify communities underserved by urban forest green infrastructure (USDA Forest Service, 2014) Understand benefits of tool for means of advocacy and urban forest management

[1] Grade Band: Middle School, Discipline: Life Sciences, Disciplinary Core Idea: Ecosystems: Interactions, Energy, and Dynamics, Performance expectation: 5.

[2] Grade Band: High School, Discipline: Life Sciences, Disciplinary Core Idea: Ecosystems: Interactions, Energy, and Dynamics, Performance Expectation: 7.

Appendix B: Module Learning Outcomes

Module Title	**Learning Outcomes**	
FEATURE	FUNCTION	PRACTICAL APPLICATION
Explore Location Data	Select geographic area (i.e. census tract, city) for visualization In selected geographies, show area, land and tree cover, forest composition, pest threats, census data, forest and health risks, and future climate predictions	Education on social and scientific contexts of urban tree planting[1,2,3] Effective urban forestry management considering climate change[3]
See Tree Benefits	In selected geographies, show associated benefits of tree cover (i.e. CO_2 storage and sequestration, air pollution removal, avoided stormwater runoff, rainfall interception)	Education on ecosystem services provided by urban trees[1,2] Methods for valuation of ecosystem services[2,3] Education on spatial differences in ecosystem services[1,2,3]
Prioritize Tree Planting	Prioritize tree planting across multiple geographic areas (i.e. census tracts) based on common scenarios (i.e. high population, high poverty), or custom scenarios (i.e. low avoided runoff)	Advocacy[3] Land management[3] Education on spatial differences in ecosystem services[1,2,3] Using map layers to find possible planting locations within high priority geographies[3]
Generate Results	Create pre-formatted reports showing data from previous pages in the form of tables, charts, or maps Export data	Advocacy for urban forest management[3] Effective visual representations of inequality in tree cover and associated benefits[3]

[1] Focus in materials for middle school students
[2] Focus in materials for high school students
[3] Focus in materials for college students, urban forestry practitioners, and community organizations